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THE CONTRIBUTIONS OF ASTRONOMY TO CIVILIZATION

THE principal duty imposed upon the president of the Pacific Division is the delivery of an address at the annual meeting. In some respects this duty is an embarrassing one for the present incumbent. This is preeminently an astronomical occasion, and your president is not an astronomer. With no original message of his own, he can perhaps best fulfill his obligations by reminding those who are gathered here of some of the great contributions which astronomy has made to civilization.

If the earth were alone in the universe human life could not exist. With the sun to give essential warmth and light, life would be possible; but imagine if you can how the progress of mankind would have been retarded if there were no stars, or if the pioneers of astronomy had failed to discover how to use their apparently uniform rotation as a measure of the flow of time and the axis of this rotation as a standard of direction. The north star was a faithful guide to the traveler, and without it Columbus might well have hesitated to embark on his perilous journey in search of a new world. The first astronomers, without instruments, must first have noticed the rotation of the fixed stars about the axis passing through Polaris, then the orderly annual precession due to the motion of the earth in its orbit. The seemingly erratic motions of the planets must have puzzled them, but in time the orderly sequence of their motions with respect to the earth was recognized and correctly described in Ptolemy's theory of epicycles. As time went on, accumulated observations and deductions therefrom gradually made clear our relations to the solar system. Copernicus revived the bold guess made by others centuries before, that the earth and planets revolve about the sun. Galileo, with the enlarged field of vision due to the telescope, found reasons to support that guess, and Kepler formulated the laws which almost exactly describe the motions of the planets in elliptic orbits around the sun. Newton proved that the same force which causes bodies to fall to the earth, causes the moon to revolve about the earth and the earth about the sun. This discovery made celestial mechanics an exact science.

Mathematical astronomy has made it possible to establish standards of time and to make exact surveys of the earth, and enables the navigator to find his position and determine his direction at sea. When his observations are made impossible by cloud or

fog and he is compelled to rely upon the uncertain aid of compass and log, the sailor realizes what he owes to astronomy.

In making an exact chronology and exact surveys of the earth possible and in facilitating maritime intercourse between nations, astronomy has rendered a practical service which all must recognize, and which is of inestimable value to civilization. But civilization means more than material welfare. It means the extension of man's range of thought beyond his immediate surroundings and the constant effort to discover his relations with the universe; it means an understanding of the phenomena of nature on this earth and in all the heavenly bodies accessible to our sight; it means the projection of our mental vision backward to the remote past and forward into the distant future; it means an understanding not only of the evolution of man and of society, but of the evolution of worlds; it means the formulation of a consistent hypothesis regarding time and space and their relation to each other, and it means a constant effort to develop the esthetic and spiritual values of life, which must be closely associated with the physical phenomena which affect our lives and thoughts and which are the direct objects of scientific study. It may mean other things as well, but to all of these elements of civilization at least astronomy has made notable contributions, and upon it alone must we depend for our knowledge of what lies outside this tiny atom which we call the earth.

By successive steps Ptolemy, Copernicus, Kepler and Newton made clear the relations of the earth to the solar system. Later observations on the orbits of double stars showed that the law of gravitation holds good to the remotest regions visible through the telescope. The spectroscope shows that the sun and the stars are made of the same materials as the earth, thus proving the material unity of the universe. The spectroscope and the telescope have enabled us to extend our observations to any heavenly body from which light brings its message, and slowly but with increasing certainty the astronomer is learning to interpret these messages and to journey in imagination to far distant worlds.

The spectroscope tells us how fast the stars are moving in the line of sight with respect to the earth, and by analyzing such results, Campbell and others are able to tell us how rapidly and in what direction the solar system is traveling through the stars. Furthermore, spectroscopic observations, interpreted with the aid of researches made in the physical laboratory, give definite information concerning not only the constitution, but also the temperatures and the densities of stars. The angular diameters of many stars have been determined by Michelson's interferometer method, and in cases where the distances are known the actual diameter can be calculated. So far away are they that only in comparatively few cases can their distances be determined by triangulation, using the diameter of the earth's orbit as a base line, but Adams has shown how we may determine their distances, no matter how great these distances may be, from definite and easily observed relations between their apparent brightness and the peculiarities of the lines of their spectra.

Through the action of gravitational forces, heat and chemical and radioactive transformations, every body in the universe is undergoing ceaseless change. If we can in the case of any one body discover its original condition and establish the sequence of its physical states until its life of physical activity has run its course, the problem of stellar evolution is solved, for we may be sure, from the substantial identity of constitution of all the heavenly bodies, that they will all pass through the same cycle of experience. The human race can not exist long enough to follow the life history of any one star, but from the study of individuals in different stages of development, we can, with the aid of established physical principles, infer the sequence of their stages of development.

To Kant and to Laplace we owe the first rational hypothesis of stellar evolution, but they had at their command insufficient data to establish their nebular hypothesis on a sound basis. Within the last few years astronomers have accumulated a great mass of material which gives a more secure foundation for a consistent theory of stellar evolution. In the case of hundreds of stars much is known concerning their distances, their sizes, their densities and their temperatures. From the laws of physics we know the general trend of the changes which must take place in any star. If at first it is a highly rarefied and diffuse mass of vapor at a low temperature, gravitational forces will cause its gradual condensation, and this will produce an elevation of temperature, just as the air in an automobile tire becomes hot as it is compressed. As the temperature rises, the vapor will first become red hot and ultimately white hot. After the density reaches a certain stage, condensation will proceed more slowly. When the loss of heat by radiation exceeds that produced by compression, the star will cool in reverse order from white to red heat. After it has contracted to the solid state, like the earth, the production of heat by condensation will cease, while cooling by radiation will continue, until the star loses its luminosity. This process of condensation and cooling will be extremely slow, and Eddington has pointed out that it may be prolonged by internal development of heat due to superchemical transformations made possible by enormously high temperatures and pressures. These may cause the formation of one element from another by the aggre-

gation of atoms, a reversal of the radioactive process of disintegration. If such be the sequence of changes in any star, it is evident that it must pass through the red stage twice, the first time while rising in temperature toward the white state and again while cooling. It is an established fact that there are many huge dark nebulae which may be the original stuff of which stars are made, and that the red stars can be separated into two well defined classes of giants and dwarfs, differing enormously in size and density but little in mass. These large differences in size are not found in the white stars, which are all, according to this hypothesis, in the same stage of development. It is mainly to Russell that we owe this hypothesis of stellar evolution from a dark diffuse nebula passing by condensation through the giant red stage to the white stage, then back to the dwarf red stage, ultimately to become a dark solid body. This theory, while not entirely free from criticism, is a beautiful and logical picture of stellar evolution. What may be the final destiny of the dark bodies which are the final product, we can only guess. Hundreds of thousands of such dead and invisible worlds must exist, most of them perhaps destined to wander through space for all time, but some of them may, by collision with other bodies, be again resolved into glowing vapor and begin a new cycle of existence.

The distances and the magnitudes of the stars and the duration of their stages of development are beyond the grasp of human imagination. On the other hand, recent developments in physics show that in all probability every atom is the analogue of our solar system, with electrons revolving like planets around a central nucleus charged with positive electricity, in orbits so small and in periods so short as again to elude our imagination. The one element that we can grasp in comparing an atom with the solar system is the relation of the parts of each to the whole, not the absolute values of the magnitudes and the periods of time in each.

The idea of relativity, first applied by Newton to motion and extended by Einstein to include all the relations of space and time and matter, is one which is perhaps destined to exert a greater influence upon thought and conduct than the idea of evolution, and it is to astronomy that we must look for the final tests of its validity.

Newton clearly conceived the idea of relativity of motion as we actually observe it, although he believed that in fact there might be in the universe some fixed point of reference, if we could only find it. We may measure the velocity of a body with respect to the earth, but the earth itself revolves on its axis and at the same time moves around the sun. The latter is not at rest with respect to any other body, and the stars travel in chaotic fashion. If we consider the earth to be at rest, the planets move around it in epicycles. If we take the sun as the fixed center, the planets move around it in ellipses. We have no means of knowing, or even of imagining the true orbits of these bodies in space. Newton expressed the belief that "absolute space, by virtue of its own nature and without reference to any external object, remains the same and is immovable." Although many held to this view up to our time—perhaps some still do—there seems to be no way by which the absolute motion of bodies through this immovable space can be determined. For a time, however, the general acceptance of the wave theory of light revived the hope that such absolute motion might be detected. The waves with which we are most familiar, such as those of water and sound, are periodic displacements in a continuous medium, and it seems impossible to imagine any waves without some medium through which they may be propagated. This gave rise to the hypothesis of a universal ether, the medium of light waves and electro-magnetic phenomena. Various attempts have been made to determine the motion of the earth through this hypothetical stationary ether, the most famous and significant of which was the Michelson-Morley experiment, first performed nearly forty years ago and repeated several times, always with a negative result.

To illustrate the effects which might be expected, let us consider a familiar example of wave motion, that of sound, which is transmitted through the atmosphere. In 1915, from my home in Berkeley, I could see the flash of fireworks in the Exposition grounds in San Francisco, and from 49 to 54 seconds later the sound of the explosion could be heard. The difference in time was due to the varying direction of the wind. The velocity of sound in the air was in each case the same, but the air itself was transported with the wind, sometimes toward me, sometimes in the opposite direction. The apparent velocity of the sound was the resultant of these two velocities. Similarly, if an observer is stationed on a moving train, the velocity of sound waves through the fixed atmosphere appears to him to be greater if the train is moving toward the source, less if it is moving away, and since the velocity of the sound waves in the stationary atmosphere is known, the velocity of the train with respect to the atmosphere can be calculated. Similarly, if light waves are propagated in a stationary ether, and if the earth moves with respect to the ether, we would expect the measured velocity of the light to vary with the direction of motion of the earth in such a manner that the motion of the latter with respect to the fixed ether could be calculated.

The Michelson-Morley experiment, carried out with the utmost precision, showed that in all positions of the earth in its orbit the observed velocity was the

same, both in the direction of the earth's motion and at right angles to this direction. It was thus proved that the velocity of light appears to be the same to all observers, whatever may be their velocities relative to each other or to the earth. We are forced to the conclusion that it is impossible to determine uniform absolute motion through space by any optical method, and no other method can be imagined.

The experimental conclusion that the velocity of light is the same for all observers, regardless of their relative velocities or directions of motion, a fact so utterly at variance with results observed in the analogous case of sound, seems, from the standpoint of our experience, to be a logical contradiction. In seeking for an explanation, we are driven to the conclusion either that the motion produces a change of length in our apparatus and measuring instruments in the direction in which they move or that the perceptions of space and time are different for observers moving relatively to each other. The first of these alternatives was suggested by Fitzgerald and elaborated by Lorentz. The failure of the Michelson-Morley experiment could be accounted for if the dimensions of the apparatus used were shortened in the direction of the motion of the earth. This seems a plausible suggestion, because we know that a material object moving through the air would be slightly shortened in the direction of the motion by air pressure. In the latter case, however, a steel bar would be shortened less than a wooden bar, whereas Michelson and Morley used a number of materials in their apparatus, all with like result. It would, moreover, be a strange coincidence if the contraction should in every case, for all velocities and for all substances, be exactly of the magnitude to produce compensation.

Einstein in his earlier special theory of relativity sought a more general explanation which leads to the surprising conclusion that there is nothing absolute in our measurement of space and time intervals, but that they will be different for two observers moving with uniform velocity with respect to each other. A fundamental postulate of classical mechanics is that the time interval between two events and the distance between two points in a rigid body are the same whether measured in the system to which they belong or observed from another point of reference moving with respect to the first. All our measurements of time and space depend directly or indirectly upon the use of light signals, and hence will be dependent upon the facts that the velocity of light is finite and its apparent velocity the same for all observers. These measurements depend upon sense perceptions which may not correspond to the real world in any absolute sense. It is not possible here to enter into a detailed discussion of this subject, but Einstein showed by simple and irrefutable algebraic calculations that if an observer regards himself as at rest, the dimensions of objects and the durations of events in a system moving relatively to him will appear to be changed. For example, if the aviator in a rapidly moving aeroplane waves his arm, it will appear shorter when in the horizontal than in the vertical direction, and the duration of the gesture will appear to increase with the speed of the aeroplane. The aviator is not aware of these changes; on the contrary, to him objects on the earth appear to be shortened and intervals of time lengthened. In each case, the calculated expression for the shortening is identical with the Fitzgerald-Lorentz contraction formula. Which observer is correct in his conclusions? The answer is that both are. It is not necessary to assume any real contraction in an absolute sense in either case. Because the velocity of light is the same for all observers, the time and space intervals which have certain values for an observer in one system will not appear to be the same to an observer in another system moving with respect to the first. The differences are very small unless the relative velocity is very great, and we can not hope to observe them in ordinary cases. Cathode rays and the beta rays from radioactive substances, and electrons rotating in atomic orbits, move with speeds approaching that of light, and in these cases some of the consequences of the special theory of relativity have been verified. One of these consequences is that the mass of a body is not constant, but varies with the speed, so that mass is also relative.

Thus it appears that not only uniform motions, but lengths, intervals of time and masses are relative and will appear different to two observers moving relatively to each other. Moreover, it follows from the same considerations that it is impossible except in special cases to determine whether two events are simultaneous or not. Newton believed that "absolute, true and mathematical time flows in virtue of its own nature uniformly and without reference to any external object." We now realize that this, like his conception of absolute, immovable space, is a metaphysical conception, corresponding to no physical reality which we can ever hope to establish.

From such considerations, it appears that our last hope of any absolute knowledge of the physical world is destroyed. With no objects or only one object in the universe, space would be meaningless. With the appearance of two objects at a measurable distance apart space is created, but this distance is not the same for different observers. With no object, or one object subject to no internal changes, time would be meaningless, there would be no past, no future, only an eternal present. If changes take place in an object, or if another object moves with reference to it, time is created, but the rate of flow of that time

will appear to be different to an observer in another moving system. We speak of the uniform rotation of the earth, but if its period should change and the period of revolution of the earth in its orbit should change in the same proportion, we would never know the difference, except that our lives might appear to be lengthened or shortened. If the rate of our bodily processes also changed in the same proportion, our lives might be lengthened or shortened a thousand fold, and we would never know it.

That there is a real world outside of ourselves, no physicist doubts, but it is full of illusions and we can learn little about it with our unaided senses. When we supplement these senses with such aids as the telescope, the microscope, the spectroscope, the photographic plate and the instruments used for detecting electric and magnetic effects, we can learn much concerning things lying outside the range of our sense perceptions, such things as ultra-violet and infra-red radiations, X-rays and many electromagnetic phenomena. Most of our scientific knowledge, especially that concerned with atomic phenomena, is based not directly on sense perception, but on inferences so logical that we feel satisfied with their validity, but after all they are only inferences.

The aim of scientific inquiry is to obtain descriptions of the external world which will be the same for all observers, that is to say, what are called invariant relations. The special theory of relativity shows that we can not obtain invariant relations of physical phenomena in terms of space alone or of time alone. Minkowski first called attention to the fact that the two are inseparable. Physical phenomena are events which occur at given points of *space* which may be specified by rectangular coordinates measured from a definite point of reference, and at a definite instant of *time*. Minkowski showed how to construct the mathematical expression for a combined time-space interval between two events which would be an invariant for all axes of reference moving with uniform velocity with respect to each other. In a two dimensional plane space, the square of the hypothenuse of a right-angled triangle is equal to the sum of the squares of the sides. If the hypothenuse is the distance between two points on a plane, it is invariant, but there are an infinite number of pairs of sides the sums of the squares of which will be equal to the square of this distance, all depending upon the orientation of the axes of reference. In three-dimensional space the square of the diagonal is equal to the sum of the squares of the sides of a right-angled solid, which again may have an infinite number of values. Time is not space, but it is one of the elements which fixes an event. Minkowski represents the joint space-time interval between two events by the length of what he calls a world line, which, by analogy with the length of the diagonal of a right-angled solid, is so defined that its space is equal to the sum of the squares of the three rectangular space coordinates of the event and the square of the time interval multiplied by a coefficient which we need not consider here. The length of a given world line is invariant, but associated with it are an infinite number of possible space and time coordinates, which may be regarded as the projections of the world line on variously oriented axes. Thus various values of the space intervals and time intervals measured along these axes may be associated with the length of a given world line between two events. This four-dimensional continuum fits the case of special relativity. For example, two events, such as flashes of lightning, may take place at different points at different times. To two observers in relative motion with respect to each other, the distance and the interval of time between these two events will appear different, but the expression for the combined space-time interval, the length of the world line, will be the same for all observers. By the application of this principle, all the laws of physics can be expressed in invariant form for all systems of reference having uniform rectilinear motion with respect to each other.

We need not vex ourselves with the futile attempt to visualize this apparently four-dimensional world. It is not four-dimensional in a purely spatial sense. It happens that the three dimensions of space are evident to our senses. We also think we have a definite notion of the duration of time, but it is not a notion which we can visualize, so that we need not expect that the combination of the time dimension with space dimensions will be evident to our senses. In fact, even the third dimension of ordinary space is to some extent an inference. A totally paralyzed person with one eye would perceive the external world only by means of a two-dimensional image thrown on his retina. He sees little more than he would in a photograph on a flat surface. With two eyes he would get an inkling of the third dimension through perspective, but only by moving his hands and legs and going from place to place could he perfect his notion of three dimensions. We must reconcile ourselves to the fact that our sense organs are too imperfect for us to perceive all that goes on in the world around us. It is futile to attempt to describe a symphony to one who has been deaf from birth or color to one who has always been blind. Yet it is possible to give to the deaf and the blind an idea of the sound waves and the light waves which may produce the sensations of sound and color in others more highly endowed. This analogy may reconcile us to our inability to visualize the four-dimensional world of Minkowski, and yet allow us to believe that the mathematical expression for the lengths of his world lines correspond to physical realities.

To prepare our minds for the reception of Einstein's later theory of general relativity we must submit to a still greater strain upon our credulity. We must not only accept the idea of four-dimensional time-space in a mathematical sense, but we must consider the consequences of a possible curvature of this space. On a plane surface the square of the diagonal of a right-angled triangle is equal to the sum of the squares of the sides. Such a space is called Euclidean. We have a similar expression for the diagonal of a cube in three-dimensional space, which is likewise Euclidean. By analogy, we may call Minkowski's four-dimensional space Euclidean if the square of the world line is equal to the sum of the squares of the space and time coordinates. But consider a curved surface, such as that of a calm lake. It appears to us to be plane, but we should find that if the lengths of the sides of a right-angled triangle are measured on this surface, the sum of the squares of the sides will not be equal to the square of the hypothenuse. The mathematician can prove that this indicates a curvature of the surface, and he can determine from the measurements how great the curvature is. Such a surface is not Euclidean. In Minkowski's four-dimensional time-space world, the sum of the squares of the space and time components of an event is ordinarily equal to the square of the length of the world line. In cases where this is not so, but one or more of the squared terms are multiplied by a factor different from unity, we may say that this space is curved. The shortest line between two points in a plane surface is a straight line. The shortest line between two points on a spherical surface is a curved line, part of a great circle, and is called a geodesic line. By analogy, we may consider that in Minkowski's four-dimensional world a world line is curved when the space is curved, and we may call it a geodesic line. We may represent the space-time interval between two successive ticks of a moving clock by the expression for the length of a world line. In curved space the successive world lines representing intervals between ticks would when joined, end to end, not lie on a straight line.

It is the later general theory of Einstein which is of most interest to us here, because its tests are entirely astronomical. The special theory of relativity applies only to uniform motion. In the case of accelerated motion there seems to be an absolute element. Acceleration is the rate of change of velocity. We can not detect our uniform motion through space, for example on a ship moving in calm water, but if the ship is suddenly stopped we become very much aware of the change in velocity. If we apply a mechanical force, such as a direct push or pull, to an object, its motion is accelerated. Conversely, if we observe that a body is accelerated, we infer the action of a force. An unsupported body falls to the earth with accelerated motion. We attribute this to a hypothetical force called gravity. The earth is subject to a uniform centripetal acceleration toward the sun, which we attribute to the same force. Gravitation has always been one of the great mysteries of the physical world. If a stone is whirled around at the end of a string, it is easy to visualize the force as due to the direct pull of the string. In what way does the sun exert its pull upon the earth? Action at a distance is repugnant to our minds, and it does not help us to imagine the ether as the medium through which this force is exerted, for earth and sun alike seem to slip freely through this ether. We might as well try to imagine the ocean pulling two ships together. We do not know nor can we ever expect to know the mechanism of gravitation. The Newtonian law merely describes the effect of this hypothetical force. If it turns out that the Newtonian law is an inadequate statement of observed facts, we shall need to correct it, and this is what Einstein has done in his general theory. We are satisfied to accept the Newtonian law because we have grown familiar with it, although we do not understand its physical basis in the least. We hesitate to accept the Einstein law, which is neither more nor less mysterious than that of Newton, because we have not become accustomed to it, yet in all probability the next generation will accept it without question and think that it understands it.

The basis of the general theory of relativity is the principle of equivalence. If we imagine a closed box in space at a great distance from attracting masses there will be no gravitative forces to consider. A man standing on the floor of the box will exert no pressure on the floor, in other words will be devoid of weight. If the box is suddenly accelerated upward, there will be a pressure created similar to that of which we become aware when in an elevator which suddenly starts upward. An apparent gravitational field is created which can not be distinguished from a true gravitational field. The two are equivalent. In general, therefore, we may say that when one reference system is accelerated with respect to another—say a ship with respect to the earth—forces are created which are equivalent to those produced in a gravitational field. For example, if the motion of the ship is suddenly checked, passengers are thrown forward as though a gravitational force pulling them toward the front of the ship had been created. A beam of light from an outside source passing through the accelerated box at right angles to its direction of motion would apparently be bent toward the floor. The principle of equivalence leads us to the conclusion, therefore, that a beam of light would be deflected in a gravitational field. A projectile moving uniformly in the same direction would appear to fall

in a parabolic path to the floor, as a projectile falls to the earth. If the light waves behaved in exactly the same manner, without loss of speed, we should get the so-called Newtonian deflection of .84 seconds of arc for a beam of light passing near the sun. But the curvature causes a change of the direction of the wave front, corresponding to a progressive decrease in velocity in approaching the sun. From this we may conclude that in a gravitational field there is a departure from the law of constancy of velocity of light assumed in the special theory of relativity, and that the change of direction of the wave front, corresponding to the case of ordinary refraction, will cause a further bending of the beam toward the sun. This causes the Newtonian deflection to be doubled, so that the predicted displacement is 1.75 seconds of arc, a prediction brilliantly confirmed by Director Campbell.

Futile as it may seem to try to understand first principles, we can not avoid speculating as to the explanation of the relative acceleration between the earth and the sun which we attribute to the force of gravitation. Newton's first law of motion, the law of inertia, asserts that a body on which no force acts, moves uniformly in a straight line. We can imagine conditions, however, in which this is not possible. Consider a two-dimensional surface such as that of a sphere to which a body is restricted, although it is free to move in any direction in this surface. In such a case if the body is set in motion, it will continue to move with uniform speed along the closest approximation it can make to a straight line, that is along a geodesic line. If we observe the motion of the body from a point outside the system and are unaware of the constraint to which it is subjected we will conclude that it is subject to an attractive force directed toward the center of the spherical surface. As a matter of fact there is no such force in this case, but the motion is determined solely by the curvature of the space in which the body moves.

When in the four-dimensional world of Minkowski the square of the length of a world line is equal to the sum of the squares of the one time coordinate and three space coordinates, we say that this space is Euclidean, that is, without curvature. It is at least formally analogous to the three-dimensional case in which the square of the diagonal of a cube is equal to the sum of the squares of the sides. In his general theory of relativity, Einstein assumes that in a gravitational field, space is not Euclidean, but curved. In such a case, as we found in the analogous case of a two-dimensional spherical surface, the coefficients of the squared terms, the sum of which is equal to the square of the world line, are not equal to unity. In such a curved space the natural path of a moving body is not a straight line, but a geodesic line. Thus the effects which we have attributed to gravitation are not dynamical, but are a direct consequence of the geometry of space. The earth moves around the sun not because it is attracted by a force, but because the law of inertia constrains it to move along the geodesic lines in the curved space surrounding the sun. By properly choosing the coefficients of his squared terms, Einstein has been able to obtain a law of gravitation which is identical with that of Newton at a distance from matter, but introduces a small correction term in the immediate neighborhood of large masses.

It is as fruitless to speculate upon the physical meaning of this apparent curvature of the space in the neighborhood of massive bodies as it is to speculate concerning any other theory of gravitation. All that we can expect of any hypothesis regarding fundamental things is that it shall lead to a mathematical law which shall as simply and exactly as possible describe observed facts, and additional weight must be attached to such hypotheses when they suggest the prediction of previously unsuspected facts and these predictions are verified by observation. These conditions are fulfilled by Einstein's theory. It exactly accounts for the anomalous rotation of the major axis of the orbit of Mercury, which is greater than that demanded by the Newtonian theory. It predicts a deflection of light waves passing by the sun which is double that demanded by the Newtonian theory, and this prediction has been verified. Another consequence of Einstein's theory is that any kind of a clock runs more slowly in a strong gravitational field. An atom emitting light vibrations is a clock, hence we may infer that the atoms in the solar atmosphere emit light waves of smaller frequency and greater wave length than the same atoms on the earth. This prediction has not yet been verified, as the predicted change of wave length is small and the disturbing factors in the solar atmosphere great, but it will not be surprising if this final verification of Einstein's epoch-making theory is found.

To sum up, we have seen that astronomy has rendered man great practical service; it has enlarged his knowledge of his environment near and far; it has given him some notion of the relation of himself and his earthly home to the universe; it has given him glimpses into the remote past and ground for speculations as to the distant future; it is unfolding the story of the evolution of worlds, and now it is unraveling some of the mysteries of time and space which have so long baffled the human mind. In addition, by adding to our general knowledge and developing the powers of the imagination, it has, in common with other sciences, directly and indirectly enlarged the ethical and esthetic values of life. Conduct is also relative; what is a virtue to-day may be a sin to-morrow. Good intentions alone can not carry

us far on the road of righteousness. To avoid blind groping, we must have that understanding of the relations of our conduct to our happiness and that of our fellow men which only the most complete knowledge of our earthly environment can give. Moreover, appreciation of the esthetic values which add so much to the joy of living seems dependent upon knowledge and the training of the imagination which it gives, for ignorant savages seem blind to the beauties of nature and unresponsive to the appeal of art.

Generous as the contributions of astronomy to civilization have been, there is promise of more to come. The universe is either finite or infinite, but our imaginations can grasp neither alternative in terms of the old ideas of space and time. On the basis of the general theory of relativity, it seems possible that astronomical observations may reveal to us a universe which is finite and yet unbounded, a self-contained universe keeping intact its store of matter and of radiant energy, with no infinite ocean of empty space around it, for there can be no space where there is no matter. This is the hope that is held out to us by Einstein and his co-workers, and to the astronomers we must leave the task of confirming that hope.

E. P. LEWIS

UNIVERSITY OF CALIFORNIA

ROBERT WIEDERSHEIM

BY the death of Robert Wiedersheim, long the professor of anatomy in the University of Freiburg i/Br., another milepost has passed in the history of the comparative anatomy of vertebrates. Five days past his golden wedding anniversary, already afflicted by an inflammation of the lungs which was not supposed at the time to be serious, he fell asleep. In his hand he held the book with which he was beguiling himself when he died, "Die Geschichte der Anatomie."

Dr. Wiedersheim was born at Nürtingen am Neckar in the Würtemburg Black Forest, April 21, 1848, the son of a physician there. Fourteen days after his birth his mother died, and young Wiedersheim was brought up in the household of his grandfather, Immanuel Friedrich Otto, owner and proprietor of a cotton mill at Nürtingen. After attending the gymnasium at Stuttgart, with a short time in Lausanne, he studied further at the universities of Tübingen and Würzburg, obtaining his M.D. at the latter place, January 27, 1872. Here also he accepted an assistant professorship under Kölliker (1872–76), refusing a call to the University of Tokio as professor of anatomy there.

In the winter semester, 1876–77, Wiedersheim came to Freiburg as the assistant of Professor Alexander Ecker, whom he succeeded there as professor of anatomy at the latter's death in 1887. Here he remained until his retirement in 1918, leaving in his position Dr. Eugen Fischer, who is there at present.

While still an undergraduate he met his wife, Tilla Gruber, daughter of a Genoese banker, a German residing with his family in Italy, and married her July 7, 1873. In 1878, he built his summer home on the shores of Lake Constance, his beloved Villa Helios at Schachen near Lindau, which served him during many vacations. Here he retired after he left Freiburg, and here he died.

Wiedersheim, although he could never be induced to cross the ocean, travelled in Europe extensively, and made one short journey to Algeria. He visited England several times, especially to attend the Darwin Centenary in 1909; he travelled extensively also in France and Italy, including Sicily.

Aside from his work in human anatomy, which made him famous all over Germany, and brought students from other universities to Freiburg to take their anatomy with Wiedersheim, he gave a course in comparative anatomy, and received private students from other countries.

In 1882 appeared his "Lehrbuch der vergleichenden Anatomie," which he soon followed by a "Grundriss," explaining the same things in a more concise manner. This latter book he much preferred, and brought out several editions, the last (7th) appearing in 1909. It was his custom to keep a manuscript of this on his desk, making constant additions and revisions for use in newer editions. It soon became one of the largest and best of the text-books of comparative anatomy. In special monographs his work, though not extensive, was yet so carefully done that each was a classic. We need only mention "Das Kopfskelet der Urodelen," his work on the ear of the Ascalaboten, and the anatomy of Salamandrina perspicillata and Geotriton fuscus.

It is a well-recognized truism that, in the World War, the intellectuals suffered most. On April 14, 1917, three hostile bombs dropped from a British airship caused Wiedersheim's laboratory to burst into flames. It was totally destroyed. The minds of men were at the time aflame; there were ugly rumors of a similar treatment of British hospitals, there was a feeling of the need of reprisals. We are sure only that in this conflagration the great anatomical collection started by Alexander Ecker, his world-famous skull collection, some 200 microscopes and numberless anatomical charts, among others some from Professor Wiedersheim's skilled fingers, were almost wholly lost. Yet in relating these incidents Wiedersheim uttered no word of blame or censure, one of the last illustrations of the kindness of his disposition. Surely, in the death of Robert Wiedersheim the world lost far more than a great anatomist; to many he was a devoted friend. With

this tribute it is the wish of the writer to place a wreath upon his bier.

H. H. W.

HERMANN M. BIGGS[1]

Dr. Biggs was born at Trumansburg, N. Y., in 1859. He was of English descent. His early education was completed at the Trumansburg and Ithaca Academies and at the Cornell University Preparatory School. Entering Cornell University in 1879 he graduated A.B. in 1882 and received the degree of M.D. from Bellevue Hospital Medical College in 1883, thus accomplishing seven years work in three and one half. After an interneship in Bellevue Hospital in 1883–84, he studied the following year at Berlin and Greifswald in Germany. On his return to New York he became director of the newly opened Carnegie Laboratory of the Bellevue Hospital Medical College. Then for a time he held in succession at the latter institution the positions of lecturer on pathology, demonstrator of anatomy, professor of materia medica and therapeutics, professor of therapeutics and clinical medicine, adjunct professor of medicine and in 1912 professor of the practice of medicine.

In 1892 he organized the division of pathology and bacteriology in the Health Department of the City of New York, becoming pathologist and director of the laboratories. This position he held during a period of great activity in the department because he was constantly utilizing for practical ends the new revelations of science in bacteriology and preventive medicine and in conducting a campaign of education, not only of the people at large, but in the medical profession of New York City, many of whose eminent members steadily opposed the new methods and scoffed at the new light.

In 1902, under the mayoralty of Seth Low, a new office was created in the Health Department, that of general medical officer, and Dr. Biggs was made its first incumbent.

In 1913, after twenty-two years of active service, Dr. Biggs resigned from the Department of Health of the City of New York and was soon to enter upon a not less distinguished period of service to the state. Among the outstanding features of his service to the City of New York one may recall his early acceptance of the diphtheria antitoxin as of great and immediate importance, and his eager interest in its preparation in the new laboratories of the Department of Health, the first municipal bacteriological laboratories in the world to be established. These laboratories became at once a most important factor in the control and prevention of infectious diseases in the city and a model in administration and method of the application of science on a large scale to the welfare of mankind. His rare command of the qualities of knowledge, sincerity and tact enabled Dr. Biggs, through all the vicissitudes and turmoils of the political arena in New York, through all his two and twenty years of service, to carry out, unhindered, his plans as one by one they took form, to fulfill for his fellow men the promise of science in the prevention and assuagement of disease.

Dr. Biggs' greatest achievement and his most heartbreaking task was the launching of the campaign for the prevention and cure of tuberculosis. Early diagnosis was important and notification essential to success in general control and prevention. Eager, as was his wont, to secure the counsel of his fellows, he called together a score of the most eminent physicians of the City of New York at the Academy of Medicine to discuss the feasibility of notification of tuberculosis. The eminent physicians were almost unanimous in their opposition to the taking of any official steps in the matter. They feared panic, they predicted mental disturbance of the afflicted and their friends, they forecast the ruin of boarding houses, they distrusted the effectiveness of any of the proposed measures for prevention; and who knew, anyhow, whether the tubercle bacillus was more than a fiction or a blunder of the laboratories?

So it was clear that any direct movement forward would meet with the opposition of this group at least of eminent practitioners. Dr. Biggs was disappointed, of course, but not dismayed. His quiet remark when the session was over was, "Well, we must educate them and the public." And the laboratories were one of the most effective educational influences. It was in those days quite a task to make a microscopic examination of sputum for tubercle bacilli. Dr. Biggs proposed that his laboratories should make, free of charge, examinations for everybody who might present a specimen. And they did it. And presently all the world which was awake was making free examinations of sputum. Thus, through early diagnosis, a new hope was created for the stricken. This was actually the initiation of the anti-tuberculosis movement whose achievement and promise are so gratifying, to-day.

Then visiting nurses were secured for tuberculous patients sorely needing their ministrations; there followed compulsory segregation of the careless; the creation of the Otisville Sanitarium, fit example of a beneficent municipal tuberculosis hospital; and the Riverside for the hopelessly afflicted. So after some

[1] Memorial presented by the Executive Committee relating to the death on June 28, 1923, of Dr. Hermann M. Biggs, a member of the Board of Scientific Directors of the Rockefeller Institute since its organization more than twenty years ago.

years of constructive pioneer educational work, notification of tuberculosis came without a murmur even from those who survived among the eminent score of doctors who would have none of it. In 1886, the year before the attempt to enlist the interest of the medical profession in the new crusade, the mortality from tuberculosis in the City of New York was 3.55 per thousand of population. In 1910 it was 1.85; in 1920 it was 1.09; in 1922 it was 0.85.

Dr. Biggs seemed always to be devising some new means for the improvement of the public health. He was a man of constructive vision. Working through others, his accomplishments were prodigious. The bureau of child hygiene in the New York City Health Department was organized and grew into its great accomplishments under his inspiration.

He was a member of the Quarantine Commission which in 1892, under the auspices of the New York Chamber of Commerce, was concerned in rescuing from the hands of an incompetent commissioner a fleet of passenger ships bearing Asiatic cholera which were steadily massing in the lower bay without intelligent attempt to cleanse and discharge them. He was interested in the state quarantine so early as the period when it was the unquestioned practice of the then official health officer of the Port of New York to carry out—for a fee—the disinfection of ships from suspicious ports by burning a lump of sulphur in an iron pot set on the open deck forward, no matter which way the wind blew. For many years he was a member of the consulting board of Alvah H. Doty, the accomplished quarantine officer of a later day.

In 1917 he was head of a commission sent by the Rockefeller Foundation to study tuberculosis in France. He was also a member of the war relief commission of the Rockefeller Foundation and a member of the Council of National Defense. He was a member of the International Health Board of the Rockefeller Foundation. In 1920 he was for a time medical director general of the League of Red Cross Societies at Geneva. His services were always at the disposal of organizations for the advancement of the general welfare. He was attending or consulting physician to various hospitals in New York. He was a member of many learned societies. He was the recipient of academic and other honors. He was honorary fellow of the Royal College of Physicians of Edinburgh and of the Royal Sanitary Institute of Great Britain. In 1908, for distinguished work on public health, the order of Knight of Isabella the Catholic was conferred upon him by the King of Spain. He translated Hueppe's "Methods of bacterial investigations," one of the early books to get into English telling of the new world which was unfolding itself down on the border land of life, and was to prove of such vital significance to the well-being of mankind. He published papers on many subjects relating to the public health. And withal, he was a busy and successful practitioner of medicine.

In 1913, in the midst of the preoccupations of such a busy life as has been here portrayed, Dr. Biggs was appointed by the governor chairman of a commission to revise the public health law of the State of New York. Bringing to this task his great experience, his sound judgment, his remarkable constructive vision, his commission framed a law which may safely be called a model and whose principles and details have been widely followed throughout the United States. One of the notable features of this law over which Dr. Biggs had pondered long was the establishment of a Public Health Council of seven members to advise with the commissioner of health on all matters concerning which he might seek counsel or on which as students of the practical workings of the department they might choose to tender advice. The council is invested by the law with large powers of sanitary control through its authority to establish a sanitary code and from time to time to revise and mould it to meet the requirements of science, new methods in sanitation and the changing economic conditions of the time. In 1914, Dr. Biggs was appointed by the governor state commissioner of health and chairman of the Public Health Council.

Under the leadership of Dr. Biggs, order soon established itself in the department and a new spirit of loyalty to the service and its chief awakened. Health supervisorships of districts were created as paid offices, persistent effort was made to give to the position of local health officer throughout the state a dignity and recognition which had long been wanting and to secure more capable incumbents. The laboratories soon lost their forlorn incompetencies and under the guidance of Dr. Wadsworth, became adequate representatives of science and of the spirit of the new day in preventive mediicne.

One of the early accomplishments among his activities as commisisoner of health of the State of New York was the reorganization of the work for children, and very soon an efficient division of infant and maternity welfare was spreading its beneficent influences even to the remotest corners of the state. In 1913 the State of New York (exclusive of New York City) had an infant death rate of 120 per each thousand living births. In 1922 the infant death rate was 81.

It became a high privilege to serve on the Public Health Council if for no other reason than to see with what quiet, unobtrusive efficiency the commissioner carried the supervision of all the various lines of intense activity throughout the state. He was patient, except with sheer incompetency or neglect. His plans were well considered and far seeing; he was wise in

reading public opinion. And he could always wait. If his carefully matured project for some new public health activity which science and the time seemed to have made feasible went shipwrecked on legislative stupidity or on political ambitions or on professional jealousies, he never railed but serenely sought some other way or patiently bided his time awaiting, or more commonly, assisting, the slow growth of mass enlightenment.

Under his leadership the policies and organization of the Health Department of the State of New York have steadily developed until at the time of his death it was one of the most effective ministers to the public health in the United States and one of the foremost in the world.

It was obvious when the Board of Scientific Directors of the Rockefeller Institute was being formed that his intimate knowledge of the domain of public health, practical medicine and the new outlooks in research which were so inspiring at that time should lead to the selection of Dr. Biggs as one of the men to initiate the new venture. His interest in the progress and successes of the Institute has been keen. He has been most helpful in the deliberations of the board as well as in the adjustments of the relationship of the Institute to outside phases of practical medicine and research.

He was wise in counsel, he was ready in service, he was a good comrade; we shall miss him on this board.

SCIENTIFIC EVENTS

EXPERIMENT STATIONS IN FINLAND[1]

AGRICULTURAL experimentation in Finland is now being reorganized under a law passed this year, putting this work on a permanent basis. Research is now being conducted mainly by eight institutions. Of these the Central Agricultural Experiment Station situated at Dickursby, Anas, about 10 miles from Helsingfors, is operated by the government. It is organized into departments of plant cultivation, agricultural chemistry and physics, biology of domestic animals, plant bacteriology and diseases, and agricultural entomology. Each department is under the direction of a professor of the University of Helsingfors, and the staff also includes an assistant and a clerk with university training. Besides comparative vegetable tests, plant breeding is carried on, special attention being given to the breeding of oats. Many students of the agricultural department of the university are given training each year.

The Government Bureau for the Examination of Butter and other Edible Fats is situated at Hango. Its principal work consists in the examining of butter to be exported from the country, but it also conducts investigations of other food fats. It has a staff of dairy experts and chemists.

The Economic Investigational Bureau of the Agricultural Administration at Helsingfors conducts inquiries based on data procured from several hundred privately owned farms. The chief object is to furnish information in regard to the costs of agricultural production and the profitableness of various sized farms in different parts of the country.

The agro-geological section of the Geological Commission, also at Helsingfors, conducts investigations in regard to soils and prepares agro-geological maps for the different sections. This institution is maintained with state funds.

The Swamp Cultivating Experimental Station of Lettensue, about 75 miles north of Helsingfors, is owned by the Suomen Suoviljelysyhdistys (Finland Swamp Reclamation Society), which receives financial aid from the state. The station conducts experiments in the cultivating, ditching and fertilizing of swamps. Similar stations are located at Ilmajoki, about 270 miles north of Helsingfors, where special attention is given to pasture studies on peat bogs, and at Tohmajarvi, about 417 miles east of Helsingfors.

The Plant Breeding Station of Tammisto at Malm, about seven miles from Helsingfors, is owned by the Keskusosuusliika Hankkija (Hankkija Cooperative Society). Its work consists in the breeding of the more important plants, and it is under the direction of a trained specialist.

In addition to the foregoing, the cattle breeding societies operating in Finland and receiving state aid conduct, in connection with the keeping of records of purebred stock, investigations in regard to the heredity of domestic animals. Of these societies the most important are the Society for the Breeding of Ayrshires at Helsingfors, the West Finnish Society for the Breeding of Domestic Animals at Karkku (near Tammerfors), and the East Finnish Society for the Breeding of Domestic Animals at Kuopio.

[1] From the *Experiment Station Record.*

ROTHAMSTED EXPERIMENTAL STATION

ACCORDING to the London *Times,* the report of the Rothamsted Experimental Station, Harpenden, for 1921–22, which has recently been issued, contains information which will be of value to the agricultural community. Perhaps the most significant remark in the whole report is contained in a comment on the expenditure and cash returns per acre of the ground cultivated by the station. Profits are shown in the period from October, 1919, to September, 1920, but thereafter practically every item is a deficit, and it is observed that "from 1920 onwards the financial results are deplorable and show clearly why many of the arable farmers of to-day are in their present position."

The station, which has been in receipt of government grants since 1911, has been organized so as to bring it into touch with modern conditions of agriculture, on the one side, and with scientific advance, on the other. Its activities range from oil cultivation to fertilizer investigations, the effect of manures on crops, and plant diseases. As the fundamental basis of agriculture is the production of crops, the work at Rothamsted is mainly concerned with this, and the natural subdivisions of the investigation are soil cultivation, the feeding of crops, and the maintenance of healthy conditions of plant growth. Cultivation has been reduced almost to a fine art, but as costs are the dominating factor in practical farming experiments are continually carried out with the object of discovering means of reducing expense. For instance, the power needed for ploughing can be reduced by suitable treatment of the land. Chalking heavy soil may effect a saving of as much as 15 per cent. in the power used, while farmyard manure, coarse ashes and even artificial manure can all effect similar economies.

As more than thirty artificial manures are now available to the farmer, and as their effect varies on different farms and with the weather, there is an obvious need for some general rules by which farmers may be guided. The report, having stated that a risk must always attach to crop yields, adds that it is hoped that they may eventually become calculable and therefore insurable. The difficulties of the work are great, but they are being steadily overcome, though at present the effect of differences in soil type and climatic conditions are not known with certitude for various parts of the country.

The complete report may be obtained from the Secretary of the Rothamsted Experimental Station, Harpenden.

SYMPOSIUM ON HEAT TRANSFER

A SYMPOSIUM on heat transfer will be held at the spring meeting of the American Chemical Society, under the auspices of the Division of Industrial and Engineering Chemistry.

While the final program is not available, a number of papers are in preparation by writers well versed in various applications of heat transference. These papers may be classified as follows:

Heat Losses by Radiation plus Convection, through Bare and Insulated Surfaces.
- a. From Pipes.
- b. From Furnace Walls.
- c. From Miscellaneous Shapes.

Heating or Cooling of Non-Condensable Cases.
- a. The Warming of Air in Hot-blast Heaters.

Heating or Cooling of Liquids Flowing Inside Pipes.
- a. Water.
- b. Oils.

Condensation.
- a. In Surface Condensers and Water-heaters.

Evaporation.
- a. The Analysis of Certain Comparative Tests on Evaporators.
- b. Heat Transfer in Enameled Apparatus.

Miscellaneous Topics.
- a. "A Heat Meter."
- b. The Determination of Air in Steam, and the Importance of this Factor in Heat Transmission.

In order that those interested may have ample time prior to the meeting to prepare discussion of these papers, it has been decided to issue advance copies, or preprints, bound under one cover. To this end it is necessary that the complete manuscript be in the hands of the chairman not later than January 15, 1924.

Professor W. H. McAdams, of the Massachusetts Institute of Technology, is chairman of this symposium. It is of such an important nature that two half days will be devoted to the presentation and discussion of papers.

Should preprints be issued, a copy will be sent to each paid member of the division.

ERLE M. BILLINGS,
Secretary

THE SEISMOLOGICAL SOCIETY OF AMERICA

AT a meeting of the board of directors of the Seismological Society of America held in San Francisco on October 19 the following officers were elected for the year 1923–24: Bailey Willis, of Stanford University, *president;* W. W. Campbell, University of California, *first vice-president;* R. W. Sayles, Harvard University, *second vice-president;* H. O. Wood, Carnegie Institution, *third vice-president;* S. D. Townley, Stanford University, *secretary-treasurer.*

During the past year the Seismological Society published a large Fault Map of California on the scale of eight miles to the inch. This has been distributed to the members of the society and subscribers to the quarterly *Bulletin* published by the society, and the remaining copies are now on sale. The sale of the maps is in charge of the secretary of the society, Stanford University, California. When mounted the map is 6 x 7 feet in size. The base of the map was prepared by the U. S. Geological Survey and all known active and dead faults have been drawn on it from the best information available. The map also contains the offshore contour lines from San Diego to San Francisco. These were determined by the Hydrographic Office of the U. S. Navy Department, in the fall of 1922, by the use of the Sonic method. The data of the fault lines were compiled by Bailey Willis and H. O. Wood and the publication of the map has

been made possible through the cooperation of various institutions and individuals, including the U. S. Hydrograph Office, the U. S. Navy Department, the U. S. Geological Survey, the Carnegie Institution of Washington, the University of California, Stanford University and the advisory committee on seismology of the Carnegie Institution.

During the present year the officers of the society and the editors of the *Bulletin* expect to direct their efforts toward an educational campaign for the erection of earthquake-proof buildings.

STUDY OF ENGINEERING EDUCATION

The Society for the Promotion of Engineering Education recently received from the Carnegie Corporation a communication stating that the corporation has set aside the sum of $108,000 "for the purpose of making possible a study of engineering education" under the direction of the society. The letter of President F. P. Keppel, of the Carnegie Corporation, addressed to Professor C. F. Scott, chairman of the society's board of investigation and coordination, announces that $24,000 is made available "during the present fiscal year and $12,000 during the fiscal year 1924, with the understanding that if, in the judgment of the executive committee, substantial progress shall have been made in this study by January 1, 1925, the balance of the $108,000 will be made available to the society as follows: $24,000 additional during the fiscal year 1924 and $48,000 during the fiscal year 1925."

William E. Wickenden, assistant vice-president of the American Telephone and Telegraph Company, has been appointed director of the investigation.

The Society for the Promotion of Engineering Education, which has more than 1,500 individual members and 86 institutional members, voted at its annual meeting in June, 1922, to expand its service to technical schools by a study of the training of engineers. A committee was appointed "to formulate an answer to the question, What can the society do in a comprehensive way to develop, broaden and enrich engineering education?" The report of this committee led to the organization in September, 1922, of a board of investigation and coordination, composed of Charles F. Scott, then president of the society; J. H. Dunlap, M. E. Cooley, F. W. McNair and D. C. Jackson. President Scott addressed a letter in October, 1922, to deans and presidents of engineering schools throughout the United States, "asking counsel and suggestions from the engineering schools for the guidance of the board." Abstracts from replies to this letter were printed in the November, 1922, issue of *Engineering Education,* the bulletin of the society. At the 1923 annual meeting last June, the society pledged "the support of its individual members to the proposed program of investigation of engineering education."

THE ROLLIN D. SALISBURY MEMORIAL

The University of Chicago announces that a committee, consisting of Thomas E. Donnelley, chairman, from the board of trustees; Professor H. H. Barrows, chairman of the department of geography; Professor E. S. Bastin, chairman of the department of geology, and two other persons not members of the Board of Trustees or of the University faculties, has been appointed to raise a fund of $100,000 to $150,000 to be known as the Rollin D. Salisbury Memorial Fund for the promotion of research in the fields of geology and geography.

The income from the fund is to be used for the following specific classes of projects: (*a*) Field research expeditions; (*b*) office and laboratory researches; (*c*) research fellowship grants to graduate students of special promise for the conduct of specific researches; (*d*) aid in the publication of research results when such publication can not be otherwise arranged, and (*e*) other projects that come appropriately under the caption of promotion of research.

Professor Salisbury, who for twenty years was dean of the Ogden Graduate School of Science, head of the department of geography for sixteen years, and head of the department of geology at the time of his death in 1922, left a bequest to the university of a large fund for the endowment of scientific fellowships. Dean Salisbury's influence was widely extended through graduates in geology and geography who have gone to important positions in many educational institutions.

SCIENTIFIC NOTES AND NEWS

The Nobel prize in physics has been awarded to Dr. Robert Andrews Millikan, director of the Norman Bridge Laboratory of Physics and chairman of the Administrative Council of the California Institute of Technology. The only previous award of this prize in America was to Professor A. A. Michelson, of the University of Chicago, in 1907.

The Josiah Willard Gibbs lectures, recently established by the American Mathematical Society, were to have been inaugurated this winter with an address on the Einstein Theory by the late Charles Proteus Steinmetz.

Dr. Stephen Moulton Babcock, known as the discoverer of the Babcock test for fat in milk and for research on milk, celebrated his eightieth birthday at his home in Madison, Wis., on October 22. In 1901 a medal was given to Dr. Babcock by the state of Wisconsin, bearing the inscription "In recognition of the great value to the people of this state and to the whole world of the invention and discoveries of Professor Stephen Moulton Babcock, of the University of Wisconsin, and his unselfish dedication of these in-

ventions to the public service, the state of Wisconsin presents to Professor Babcock this medal."

PROFESSOR VLADIMIR KARAPETOFF, of the School of Electrical Engineering, Cornell University, has been awarded a prize of four thousand francs by the Montefiore Foundation of the University of Liège, Belgium. The award was made for his kinematic computing devices of electrical machinery, described in the technical press during the last three years. A committee of five Belgian and five foreign members, which makes these awards, has characterized this work as an expression of a "new idea which may lead to important developments in the domain of electricity."

THE Cross of the Legion of Honor for war service has been awarded to Dr. John J. Moorhead, of New York City. This is his third decoration from the French Government. Dr. Moorehead, who is professor of surgery at the New York Post-Graduate School and Hospital, was a lieutenant colonel in the Medical Corps of the A. E. F. for nineteen months.

THE Lenard prizes for distinguished work in colloid chemistry were recently awarded by the German Kolloidgesellschaft to R. Zsigmondy, professor of inorganic chemistry at Göttingen, for his discovery of the ultramicroscope, and to Dr. W. Pauli, professor of internal medicine at Vienna, for research on proteins.

DRS. G. E. H. ROGER, dean of the Paris Faculty of Medicine, J. L. Faure, professor of surgery in the same faculty; L. J. Hugouenq, honorary dean of the Lyons Faculty of Medicine; Maurice de Fleury, member of the Academy of Medicine, and A. Lumière have been made commanders of the Legion of Honor.

PROFESSOR ALEXIS THOMSON, of Edinburgh, is about to retire from the chair of surgery in the University of Edinburgh, a post he has held since 1909.

PRESIDENT RALPH D. HETZEL, of the University of New Hampshire, was elected president of the New England Association of Land Grant Colleges and Universities at the annual meeting held at Kingston, R. I., on November 2 and 3. Dean Joseph L. Hills, of the University of Vermont, was made secretary-treasurer.

DR. DAVID D. SCANNELL, who has already served three terms of three years each as a member of the Boston school committee, has been nominated for another term by the Public School Association of that city. Dr. Scannel has been on the teaching staffs of the Harvard and the Tufts Medical Schools and is a visiting surgeon at the Boston City Hospital.

PROFESSOR WILLIAM A. WITHERS, head of the department of chemistry in North Carolina State College, was recently elected president of the Chamber of Commerce of Raleigh, N. C.

DR. MARCUS BENJAMIN, of the U. S. National Museum, represented Columbia University at the inauguration of William Mather Lewis as president of George Washington University on November 7.

W. A. MCRAE, commissioner of agriculture of Florida for twelve years, has resigned. The governor has appointed Nathan Mayo, of Summerfield, Marion County, to be his successor. Mr. McRae will be connected with a large development company in Florida.

THE Laboratory of Pharmacognosy with the Drug Control Laboratory of the Bureau of Chemistry have been consolidated. The laboratory thus formed will be designated as the Drug Control Laboratory and will be in charge of Dr. G. W. Hoover.

DR. HARRY P. SWIFT has been appointed a special deputy commissioner of health for New York City to serve without compensation.

DR. FODOR, assistant to Abderhalden, has been asked to go to Palestine to superintend the foundation and take charge of an institute for physiologic chemistry.

DR. C. A. BROWNE, chief of the Bureau of Chemistry, U. S. Department of Agriculture, left Washington on October 25 for a three weeks' trip to some of the branch laboratories of the Bureau of Chemistry.

PROFESSOR CHARLES F. SHAW, of the Department of Soil Technology, University of California, has returned from a six months' sabbatical leave spent in Honolulu, Australia and New Zealand. In Australia an extended trip was made by motor into the interior, to study soil and agricultural conditions as well as the degree of settlement and development. Many soil samples were brought back for further study.

THE sum of £100 has been granted by the managers of the Balfour Fund to Mr. Cyril Crossland, M.A., of Clare College, Cambridge, in aid of his researches into the biology of the coral reefs and banks of the South Pacific.

THE Norwegian Arctic explorer, Christian Leden, has returned from Greenland, bringing back ethnographic and zoological collections for the Peabody Museum, Harvard University.

DR. PAUL KAMMERER, of the Biological Research Institute of Vienna, will shortly visit the United States, where he will lecture.

THE annual meeting of the Sigma Xi Club of Southern California was held on Friday evening, October 19, at Occidental College, Los Angeles.

After an informal dinner, Dr. D. T. MacDougal, director of botanical research in the Carnegie Institution, delivered an illustrated lecture on "The physical basis of life." The following officers were elected for the ensuing year: *President,* Dr. Willett L. Hardin; *vice-president,* Dr. LeRoy S. Weatherby; *secretary,* Catherine V. Beers; *treasurer,* Dr. Elbert E. Chandler.

PROFESSOR HARLOW SHAPLEY, director of the Harvard College Observatory, will lecture at Brown University in the Marshall Woods Series on January 15 on "The Origin of the World."

DR. GEORGE D. BIRKHOFF, professor of mathematics at Harvard University, will give at the Lowell Institute, Boston, during the month of December, a series of six lectures on "The origin, nature and influence of relativity." The dates and titles of the individual lectures are:

Tuesday, Dec. 4—"Euclid, Newton, Faraday, Einstein."

Friday, Dec. 7—"The nature of space and time."

Tuesday, Dec. 11—"The old and new theories of gravitation."

Friday, Dec. 14—"The experimental tests of relativity."

Tuesday, Dec. 18—"Some relative paradoxes and their explanation."

Friday, Dec. 21—"The philosophical influence of relativity."

THE *Journal* of the American Medical Association writes: "Dr. Ludvig Hektoen, Chicago, is chairman of a large committee which has made an appeal to American physicians to come to the aid of practitioners, research workers and medical students of Germany who face a winter of great distress and privation. As alumni of America's universities and professional schools, the committee says, we can not afford to stand idly by while scientific and medical Germany disappears. We have shared in the benefit of antitoxins, of chemotherapy, of the Roentgen ray. We shall not want the future to record that we were indifferent when the science of a Ludwig, a Virchow, a Helmholtz, a Koch or a Fischer was in dire need. Now is the time of greatest need. The old men of the profession in Germany are in most instances absolute paupers, their life's accumulation not sufficing to buy a slice of bread. Every effort will be made to safeguard the transmission of contributions to this fund, which, if expedient, will be made through American government channels. Make your check payable to 'American Aid for German Medical Science,' and mail to Dr. Hektoen at 637 South Wood Street, Chicago."

UNIVERSITY AND EDUCATIONAL NOTES

DR. FRANKLIN CHAMBERS MCLEAN, the newly elected professor of medicine at the University of Chicago, will take part in the work of organizing the Medical School at the University. Dr. McLean has had the experience of organizing the Peking Union Medical College, upon whose buildings and equipment $9,000,000 have already been expended.

W. L. SLATE, JR., professor of agronomy in the Connecticut Agricultural College and vice director of the stations, has been appointed director to succeed Dr. E. H. Jenkins, who recently retired.

PROFESSOR C. W. PARMELEE has been made head of the department of Ceramic Engineering at the University of Illinois. He has been connected with the institution since 1916 as professor of ceramic engineering and during the past year has served as acting head.

DR. FRANK W. CHAMBERLAIN, who for five years has been acting dean of the division of veterinary science in the Michigan Agricultural College, has resigned in order to devote his full time to the department of anatomy.

THE chair of biology and pharmacognosy at the Philadelphia College of Pharmacy and Science, recently vacated by Professor Heber W. Youngken, who accepted an offer to occupy a similar chair at the Massachusetts College of Pharmacy, has been filled by the appointment of Dr. Arno Viehoever, who has had charge of the laboratory of pharmacognosy of the Bureau of Chemistry, U. S. Department of Agriculture, since 1914.

H. C. HOWARD has been appointed assistant professor of chemistry at the University of Missouri. Dr. Howard has been research chemist on the staff of the B. F. Goodrich Company.

J. S. BROWN, assistant geologist in the Geological Survey, has accepted a position for one year in the department of geology, Missouri School of Mines, Rolla, Missouri.

DR. GRUBER, formerly prosector at the municipal hospital in Mainz, has been called to Innsbruck as director of the Anatomical Institute, to succeed Professor Pommer.

PROFESSOR KUZYNSKI, a department head of the Berlin Pathological Institute, has accepted a call to the West Siberian University of Omsk, where he will serve as a pathologist, being entrusted more particularly with epidemiological research.

DISCUSSION AND CORRESPONDENCE

CLIMATIC CHANGES

DR. HUMPHREYS' review of "Climatic changes, their nature and causes," by Dr. Ellsworth Huntington and Dr. Stephen Sargent Visher (Yale University Press, 1922), in SCIENCE, Vol. LVII., pp. 389–391, March 30, 1923, conveys, I feel sure, an erroneous impression, for it fails to treat commendable features and to give any idea of the contents of the book.

"Climatic Changes" is a very comprehensive treatment of the wide subject of climatic changes in the history of the earth. The work begins with chapters on the remarkable uniformity of the climate in geologic time and on the variability of the climate. The following types of climatic sequences are distinguished: (1) Cosmic uniformity; (2) secular progression; (3) geologic oscillations; (4) glacial fluctuations; (5) orbital precessions; (6) historical pulsations; (7) Brückner periods; (8) sunspot cycles; (9) seasonal alternations; (10) pleionian migrations; (11) cyclonic vacillations; (12) daily vibrations.

A review and discussion of the principal hypotheses of the causes of climatic changes brings the treatment up to Huntington's own hypothesis, the solar cyclonic. This hypothesis is shortly as follows: Newcomb and Köppen have shown that the temperature of the earth's surface varies in harmony with variations in the number and area of the sunspots. Furthermore, Abbot has found that the amount of heat radiated from the sun also varies, and that in general the variations correspond with those of the sunspots. Sunspot maximum corresponds to the lowest temperature at the surface of the earth. Finally, it has been found that atmospheric pressure also varies in harmony with the number of sunspots. The variations are different in different parts of the earth, but systematic, and the net result is that, when sunspots are numerous, the earth's storminess increases. This interferes with the trade winds of low latitudes and the prevailing westerlies of higher latitudes, causing frequent hurricanes in the tropics and more frequent and severe cyclones in the temperate regions. With the change in storminess there naturally goes a change in rainfall. Thus, when the atmosphere of the sun is particularly disturbed, the meteorological differences between different parts of the earth's surface are strengthened.

The low temperature during times of many sunspots may be due largely to convection and to increased velocity of the winds by which the surface of the earth is actually cooled off a little. The cause of the storminess, when the sun's atmosphere is disturbed, is not quite clear, but, beside the heating of the earth's surface by the sun, electric phenomena of some kind appear to play a rôle.

Investigations have shown that sunspot cycles on a small scale present almost the same phenomena as do historic or glacial fluctuations. "When sunspots are numerous, storminess increases markedly in a belt near the northern border of the area of greatest storminess, that is, in southern Canada and thence across the Atlantic to the North Sea and Scandinavia. Corresponding with this is the fact that the evidence as to climatic pulsations in historic times indicates that regions along this path, for instance Greenland, the North Sea region, and southern Scandinavia, were visited by especially frequent and severe storms at the climax of each pulsation. Moreover, the greatest accumulations of ice in the glacial period were on the poleward border of the general regions where now the storms appear to increase most at times of solar activity."[1] "From these and many other lines of evidence it seems probable that historic pulsations and glacial fluctuations are nothing more than sunspot cycles on a large scale."[2]

After these introductory and theoretical chapters the authors take up the discussion of certain climatic problems. The headings of the chapters will give an idea of the diversity of the problems dealt with: "The climate of history;" "The climatic stress of the fourteenth century;" "Glaciation according to the solar cyclonic hypothesis;" Some problems of glacial periods;" "The origin of loess;" "Causes of mild geological climates;" "Terrestrial causes of climatic changes;" "Post-glacial crustal movements and climatic changes;" "The changing composition of oceans and atmosphere;" "The effect of other bodies on the sun;" "The sun's journey through space;" "The earth's crust and the sun."

In certain respects the undersigned disagrees with the conclusions of "Climatic Changes." Thus, when percipitation is considered to be of greater importance than temperature for the Pleistocene glaciations, it may have been overestimated. The best known glacialists, practically without exception, regard temperature as the chief controlling factor. Particularly do A. Penck, E. Brückner and A. von Reinhard regard temperature, not precipitation, as the decisive factor for the glaciations in the Alps and the Caucasus.

The nourishment of the ice sheets, according to Huntington and Visher, occurred largely by snowfall from cyclonic storms.[3] They infer that heavy precipitation and the formation of great snowfields took place first in the central areas of what later became the great continental ice sheets. Hence ice began to flow out from these centers. Later, however, the extreme development of high pressure areas over the ice

[1] P. 57, 60.

[2] P. 60.

[3] Pp. 116, 125, 136.

sheets is supposed to have forced the cyclonic storms to skirt the ice rather than cross its central parts. Our knowledge on this point is very limited, but since boulders were transported by the European ice sheets from near the center of glaciation out to the terminal moraines in central Europe, the expansion of the ice sheet to a large degree must have been controlled by precipitation in its central parts. Recently Simpson[4] has given a seemingly very good explanation of the snowfall in the Antarctic anticyclone. The precipitation, according to his view, is brought about by the low temperature of the lower strata of the air. This air is raised and cooled still further during blizzards and hence gives up the small amount of moisture which it contains.

The opinion that evaporation during the glaciation was greater than normally[5] perhaps is open to doubt, but that there was a considerable transport of moisture from low to high latitudes seems to be certain.[6]

The discussion of the causes of the disappearance of the ice sheets is not quite consistent.[7] It starts with correctly setting forth rise of temperature and diminution of precipitation as the chief general causes, but ends with largely attributing the vanishing of the different sheets of land ice to more local conditions. Most studies of the disappearance of the North European and the Labradorean ice sheets seem to show that during the ice retreat the temperature was relatively high and the precipitation slight.

Again, topographic conditions *can* readily explain many climatic problems, but their actual rôle seems sometimes to have been overestimated. So, the supposed good example of close relationship between high elevation of land and continental climate, and low elevation and maritime climate in northwest Europe during late-glacial and post-glacial time, maintained by C. E. P. Brooks, is partly unfounded, as it is based upon an incorrect interpretation of the changes of level. Even the moderate view taken in "Climatic Changes," pp. 215–222, goes too far. During the transition between the late-glacial and post-glacial periods, that is in Ancylus or boreal time, there was no extensive elevation, no continental phase as far as the land is concerned; and recently Lennart von Post seems to prove that the climate instead of being continental as supposed was maritime with dry summers and winters rich in precipitation.

In the discussion of the origin of glacial loess, which is supposed to have been accumulated mainly during the retreat of the ice, the undersigned misses references to B. Shimek, A. Jentzsch, and P. Tutkowski, who have expressed similar ideas.

A very strong side of "Climatic Changes" is that it really faces the difficulties, and takes up the problems which call for discussion, even if our present imperfect knowledge does not permit a satisfactory explanation of all of them. The solar cyclonic hypothesis seems more competent than any other existing hypothesis to explain the complexity and the rapid and heterogeneous changes of the Pleistocene climate, which are now beginning to be fairly well known, especially thorough studies in Sweden. Our present knowledge of the Pleistocene climate eliminates most and perhaps all the hypotheses which seek the causes of climatic variations in terrestrial conditions only. It seems as if Huntington has found a very important, perhaps the chief, cause of climatic changes.

ERNST ANTEVS

[4] G. C. Simpson, "Meteorology," Vol. I.—British Antarctic Expedition, 1910–1913. Calcutta, 1919. Reference on pp. 256–269.

[5] Pp. 113 ,114.

[6] P. 118.

[7] P. 128.

COLOR HEARING

I HAVE been interested for a long time in color hearing, and therefore read eagerly the article by Professor Horace B. English, of Antioch College, in SCIENCE of April 13, "And a little child shall lead them." The deductions of the three-year-old were charming.

I add my personal experience. Having met a friend in town some years ago, we fell into conversation on the possibilities of color hearing, which had been characterized as absurd. Going to my home, I said to my mother, without any preliminaries, "Mother, what color is my voice?" Without hesitation and as if I had asked her the color of a ribbon or a book-cover, she replied, "Dove-color."

I expressed my surprise that she should hear color. "Why," said she, "I have always heard color. When I went to school, there was a little girl whom I disliked very much, because she had such a yellow voice." But in all her long life (she was then over eighty) color hearing had never been spoken of. I then asked her the color of the voices of various friends, which she gave with perfect readiness. She characterized the voice of Louis Prang as having the colors of the rainbow.

Some days after this conversation, I went to New York on my way to Brooklyn to speak before an educational gathering on "Color." As I walked along Broadway, I noticed in a shop window, in which Oriental rugs were displayed, a placard which said, "A noted East Indian will tell fortunes, will read the hand and will tell the color of the voice." Feeling that I might get material appropriate to the address I was to give, I went in and was shown to a tent-like booth, in which was seated a fine-looking Hindu in full Oriental costume.

He received me in a dignified manner, read my

hand and told my fortune. I asked the color of my voice. He asked me to count to twenty and to say the alphabet. I did so. He looked thoughtful, pondered a moment, and said, "You will think it strange, perhaps—your voice is blue-violet—an intellectual voice."

It has seemed to me that the color hearing was, in the case of my mother and of the Hindu, virtually the same—dove-color and blue-violet—the elements of the colors being alike.

MARY DANA HICKS PRANG

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A HISTORICAL NOTE ON SEX DETERMINATION IN PIGEONS

IN connection with papers on sex determination in pigeons, setting forth the observations of C. O. Whitman and O. Riddle, it is interesting to find that an old French book records a part of the tradition of bird-fanciers regarding the tendency of some eggs to develop into males.

Riddle has summarized the extensive researches of Whitman and of himself as follows: "In the pigeons the first egg is smaller and is a male, the second is larger and usually a female, while as the season advances the smaller ones also are female-producers."[1]

In the reprint collection of the U. S. Fisheries Laboratory at Woods Hole, Mass., the writer recently came upon a small booklet by Jules Gautier entitled "La Fécondation artificielle," Troisème edition, Paris, 1881, which has on page 21 the following footnote:

> Chose remarquable! c'est que les oiseaux qui n'ont que deux oeufs par couvée (pigeons, colombes) en produisent un pour chaque sexe. Le premier pondu est toujours affecté au mâle, et celui-ci éclôt ordinairement avant la femelle.

The shrewd observations of breeders of horses, cattle and dogs are also deserving of consideration in planning investigations on the physiological basis of sex determination, and have already been shown to be worth nearly as much as certain clinical records.

F. E. CHIDESTER

WEST VIRGINIA UNIVERSITY

ZOOLOGICAL NOMENCLATURE

NOMENCLATURE: Notice to the zoological profession that suspension of the rules has been asked in the case of *Spirifer* Sow, 1816, and *Syringothyris* Winchell, 1863.

In accordance with prescribed routine, the secretary of the International Commission of Zoological Nomenclature has the honor herewith to notify the members of the zoological profession that Miss Helen M. Muir Wood, of the British Museum of Natural History, has submitted the generic names *Spirifer* Sow, 1816, and *Syringothyris* Winchell, 1863, to the International Commission, for suspension of rules, with a view to retaining *Anomia striata* Martin as genotype of *Spirifer* and *Syringothyris typa* (s. *Spirifer carteri* Hall) as genotype of *Syringothyris*.

The argument is presented: (1) that under the rules *Anomia cuspidata* Martin is type of *Spirifer* and *Syringothyris* is synonym of *Spirifer;* (2) but for 70 years practically all authors have, in conscious opposition to the rules, taken *A. striata* as type of *Spirifer* and *Spirifer carteri* s. *Sy. typa* as type of *Syringothyris;* (3) so many species are involved in this instance that the application of the rules would present greater confusion than uniformity.

The secretary will postpone vote on this case for one year and invites expression of opinion for or against suspension in the premises.

C. W. STILES,
Secretary

HYGIENIC LABORATORY,
WASHINGTON, D. C.

QUOTATIONS

RECOGNITION OF SCIENTIFIC WORK

L. H. BAEKELAND, just returned from an extensive trip with renewed appreciation for the opportunities and privileges of the United States, recently brought to our attention the desirability of having Congress recognize in some specific and definite way the triumphs of our men of science, particularly those in department circles. Then in the editorial section of the *New York World* for September 2, Ellwood Hendrick discussed the same sentiments and made a plea for such recognition by Congress. We wish to add our voice and urge that something be done in a proper way to have our law-makers realize that "the United States is the only civilized country in the world that does not recognize distinguished service by civilians. In the British Empire they make them lords or knights —and we can not do that. In France, Italy, Spain, Belgium, Portugal, China, Japan, and even in Soviet Russia, they give decorations. We do not give decorations to civilians. Moreover, the insignia of decorations have been preempted by so many private organizations in this country that a button in the lapel of a man's coat is without its significance elsewhere."

But there are other ways in which this Nation can express its thanks. Perhaps some day we may go as far as our neighbor Canada and grant a substantial annuity to a man who has made a scientific discovery of great importance to the public. There seems no

[1] Riddle, O., "The determination of sex and its experimental control," *Bull.* Am. Ac. Med., Vol. 15, No. 5, October, 1914.

reason why Congress could not pass an act, engrossed and signed by the President of the United States, consisting of a proper preamble and resolution commencing and expressing gratitude to a man who has devoted many years of his life, his ability as a scientist and perhaps as an inventor, to the welfare of the republic.

Such a document would be invaluable to the recipient. Moreover, the adoption of a policy of this kind might be the first step in working out a really adequate plan for rewarding scientists, many of whom have steadfastly refused more remunerative offers out of pure patriotism. Such action might be taken only upon the retirement of a departmental head or bureau chief, but those are details. The point we want to make now is that the devotion and sacrifice of our chemists to the science should be recognized in some way.—*Journal of Industrial and Engineering Chemistry.*

SCIENTIFIC BOOKS

The Psychic Life of Insects. By E. L. Bouvier. Translated by L. O. Howard. New York. The Century Company, 1922.

The behavior of the very lowest animals is determined largely by tropisms and reflexes, that is, inevitable physical responses to physico-chemical stimuli. The behavior of the very highest animals is chiefly determined by intelligence and reason. But the behavior of by far the largest number of animal kinds is mostly determined by instinct. Conspicuous and most abundant among these animals with the instinct kind of mind are the insects, constituting, as zoologists classify animals, only a single class in one of the several great animal phyla, but comprising perhaps three fourths of all the known species of animals. That means that there are approximately 400,000 different kinds of known insects. Guessing how many living kinds we do not yet know is a much pursued sport of entomologists.

Since the discovery of Fabre by the general public the psychic life of insects has been a favorite subject of reading, between new novels. Maeterlinck's "Life of the Bee" has helped to encourage this reading, while numerous other books about insect life written by men and women who know much about this life, but usually a little less about writing, are readily available to readers intent on continuing this kind of reading.

So there has gradually come to exist a considerable general awareness of the fact that insect life is a peculiarly interesting sort of life, and that it is an excellent example of behavior determined almost entirely by instinct, that is, by an inherited capacity, present from birth and but little modifiable by education or experience, to do extraordinary and complicated things connected with food-finding, protection from enemies, mating, egg-laying, care of young and whatever other things are necessary to maintain life and to perpetuate the species under most various conditions.

Now if any one, entomologist, general zoologist or layman, would like to be able to turn to a single book in which a large range and variety of insect behavior are brought together, simply described and treated analytically with the aim not primarily of telling interesting stories, but of getting at a more fundamental understanding of the springs and control of instinct, I know of no book which can be more confidently recommended to meet this desire than the book in hand. The author, E. L. Bouvier, professor at the famous Museum of Natural History in Paris, and the translator, Dr. L. O. Howard, chief of the U. S. Bureau of Entomology, are both outstanding authorities on insects, and both can write clearly and interestingly, so the book is at once reliable and lucid. If, after reading it, you are impressed more than ever, despite the book's aim of analyzing and classifying "the psychic life of insects," with the amazing complexity and wonder of this life, this is only because the more one learns about it the more one truly realizes how amazingly complex and wonderful it is.

Proceeding from a consideration of the simpler, more rigidly mechanical, and hence more readily explained kind of insect behavior—more readily explained, that is, at least as far as relation between stimulus and reaction is concerned—the author moves on to a consideration of more elaborate and complex insect habits, reaching finally the highly specialized habits of the social wasps, bees and ants, often referred to by entomologists as the "highest" insects.

Despite a strong tendency to favor a mechanistic explanation of insect behavior wherever this seems at all possible, the author is forced by the impressive seeming of an element of intelligence and reason in such specialized and complex behavior as that shown by the social insects and other less familiar but hardly less wonderful ones to assume a position with regard to the origin of this behavior which aligns him squarely with the believers in the Lamarckian evolution factor of the inheritance of acquired characters. For Bouvier assumes that much of this highly specialized insect behavior must have been originally acquired by the use of intelligence and then so often repeated as to become an inherited species habit, hence an instinct. To accept such an explanation requires two assumptions that many biologists can not accept: namely, an assumption of a considerable degree of intelligence in insects and an assumption of the possibility of the inheritance of acquired characters.

But the general reader of the book need not worry

about these things. He can well leave this worry to the biologists, and simply enjoy and muse over the amazing and fascinating wonders of life among the lowly as they are reliably and clearly described by author and translator.

VERNON KELLOGG

WASHINGTON, D. C.

SPECIAL ARTICLES

ON ABUNDANCE AND DIVERSITY IN THE PROTOZOAN FAUNA OF A SEWAGE "FILTER"*

I

ENUMERATIONS made of the animal population of the "film" held among the broken stone of a sewage purification "filter" of the intermittent sprinkling type have given data for a quantitative account of the associations and seasonal successions of these forms.[1] The abundant protozoan fauna exhibits a peculiar relation between the total number of organisms of any one class and the number of its genera then represented in the sample. Under natural conditions the abundance of organisms of any one type found in a given situation at different seasonal periods is in a general way inversely proportional to the diversity of their kinds. This phenomenon is well recognized in plankton studies and is demonstrable in published counts of organisms occurring in polluted streams.[2] In the sewage film there is on the contrary a direct correlation between number of rhizopod individuals or of ciliate individuals and the corresponding numbers of their genera. The ethological significance of such relationships seems not to have been investigated. Obviously, they are important for the problem of specific adaptation; and in this connection they suggest a means of estimating the comparative selective stringency of environments.

II

Samples of "film" were obtained from the surface and from three levels within the filter-bed, by means of a centrally-located sampling-pit analogous to that described by Johnson.[3] The figures given are the average numbers of organisms calculated present in one cubic centimeter of centrifuged fixed film material;[4] counts[5] of organisms from the three interior levels of the bed have been averaged, the surface layer being omitted. The detailed findings will be presented in another place.

Except for an interval during summer, peritrichous, hypotrichous, and holotrichous ciliates are present in abundance. Two well-defined maxima occur in the frequency of these forms, one in Nov.–Dec., the other in May–June (1921–22). These maxima correspond, in a general way, with the seasonal distributions evident in less artificial environments. When conditions in the filter permit ciliates to flourish, a variety of their species is likewise permitted. The attached peritrichs (chiefly Opercularia), whose numerical increase is subject to somewhat different mechanical conditions, are omitted from the totals plotted in Figure 1. The graph (Fig. 1) shows that with certain minor

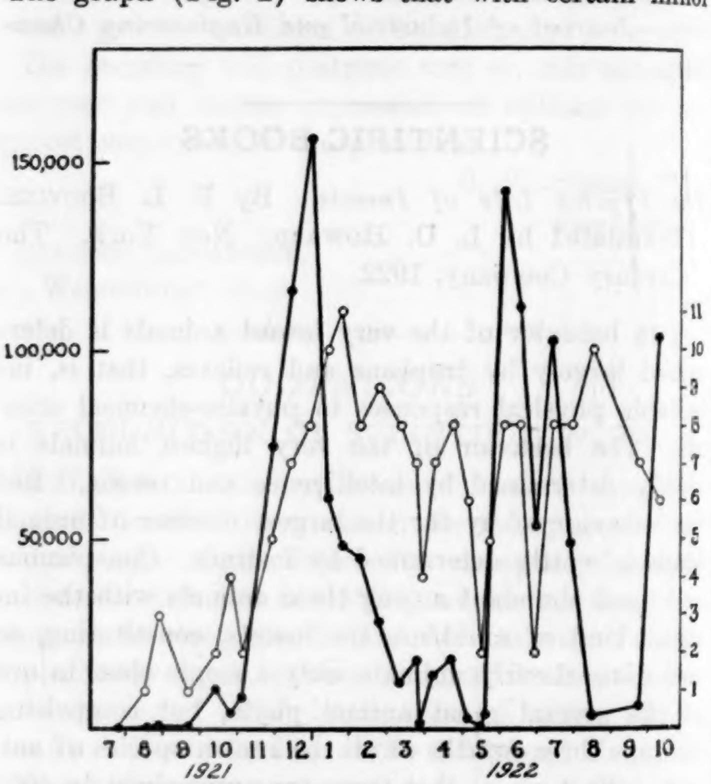

FIG. 1. Mean number of non-peritiuchous ciliates per cubic centimeter of "film" in bi-weekly samples, July, 1921, to Oct., 1922 (heavy line, ordinate scale at left). Corresponding numbers of genera (light line, ordinate scale at left).

deviations of special origin, the abundance of non-peritrichous ciliates (number of individuals per cubic centimeter of "film") varies directly with the diversity of their kinds (number of genera).

A similar relation is even more precisely shown in the rhizopod fauna. The seasonal distribution of the

* Paper No. 121 of the Journal Series, New Jersey Agricultural Experiment Stations.

[1] *Cf.* Crozier, W. J., and Harris, E. S., 1923, Ann. Rept., N. J. Agr. Expt. Stns., 1922 (in press); 1923, *Anat. Rec.*, Vol. 24, p. 403.

[2] *Cf.* data of Weston, R. S., and Turner, C. E., 1917, Contrib. Sanit. Res. Lab., Mass. Inst. Tech., Vol. X.

[3] Johnson, J. W. H., 1914, *Jour. Econ. Biol.*, Vol. 9, p. 105–124; 127–164.

[4] In the fresh, uncentrifuged film the numbers per cubic centimeter are about one half as large. The film (also studied alive) was fixed in mercuric chloride solution before counting the organisms in a unit volume of the diluted film.

[5] The collaboration of Mr. E. S. Harris in making the enumerations is gratefully acknowledged.

rhizopods shows a single maximum (Aug., 1921; 1922).

The nature of the connection between abundance and diversity, in the case of rhizopods and of (non-peritrichous) ciliates, is brought out in Figure 2.

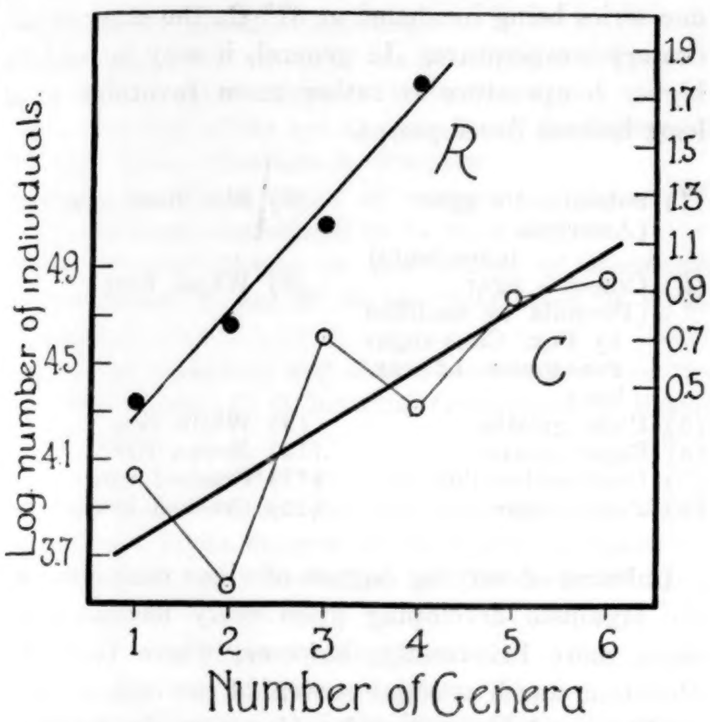

FIG. 2. Mean numbers of individuals correlated with number of genera they disclose; *R*—rhizopods; *C*—Holotrichous ciliates. (In the latter case, *C*, the period of vernal re-organization of the film, "sloughing," is excluded.)

The number of genera represented is a linear function of the logarithm of the corresponding average number of individuals.

III

From these results it may be argued that the sewage filter film is an environment of essentially artificial quality, for the relation between abundance of individuals and diversity of type is the reverse of that detected in situations lacking so plentiful a food supply for the growth of these organisms. It is to be presumed that under natural conditions the character of various specific adaptations plays a significant, even a determining rôle in survival and multiplication. Hence the view that if any one species initially present be the most suitably adapted in an environment sufficiently selective, this form will show greatest number of individuals. Whereas, if the integrated environmental effect be on the whole inimical to organisms of a particular group, a few of its species may be represented, but no one of those in especial specific selective restraint, for here diversity is at frequency. It follows that when conditions in the sewage filter "film" permit ciliates or rhizopods to flourish, there is interposed, broadly speaking, no maximum simultaneously with density of population. In all probability, therefore, temperature and gross mechanical circumstances, rather than food, limit the quantities and proportions of these particular organisms in the "film." This is consistent with the view that they are in the main subsisting upon bacteria[6] rather than directly upon putrescible constituents of the sewage.

IV

Certain difficulties interfere with the development of hypotheses concerning the meaning of specific diversity. We may safely accept the view that failure of a given type to survive in a specified location is evidence for its absence of suitability. Considering closely related types, as different genera of one order, it should be possible to obtain for different environments the curve connecting the abundance of these creatures with their corresponding diversity of forms, by means of analytic enumerations covering a period of a year or more. The widely distributed and rapidly multiplying protozoans are admirably suited for such investigation. According to the viewpoint here advanced, it should be possible to compare in this way the selective stringency or "selective potential" of different environments (with respect to the group of organisms considered). In the case of sewage "film" it is clear that environmental stress at times tends to eliminate rhizopods or ciliates, but that it is the general *kind* of creature, rather than particular species of it which is in this way suppressed. Such an environment has for these organisms no specific selective potential; the adaptive peculiarities of the species are not called into play in determining survival.

SUMMARY

In the film of organisms and débris retained among the broken stone of a sewage purification filter it is found that ciliate and rhizopod protozoans show seasonal variation in abundance of individuals and a directly correlated fluctuation in diversity of their types. An inverse correlation is recognized in natural environments of greater selective stringency. Such relationships may provide a basis for comparing the "selective potentials" of different environments.

W. J. CROZIER

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[6] This is of course to be expected; but it has sometimes been suggested that the abundant animal life of the filter film "must" contribute to purification of the percolating sewage. It is apparent, however, that in the filter food is probably never a limiting factor for these animals, even when purification is at high efficiency.

LONGEVITY IN SPORES OF ASPERGILLUS ORYZAE AND RHIZOPUS NIGRICANS

RATHER frequent reference may be found in literature dealing with the cryptogams to the belief that spores will "live for years," but when actual foundation for the truth of such statement is sought for, it is surprisingly scarce. Little seems to have been done in the way of definite, properly controlled investigation of this point, under conditions which would preclude all possibility of error in the final conclusions. It was, therefore, felt that an account of the study herein reported might be worth while if for nothing more than to bring out similar reports possibly known to other workers.

Wehmer[1] has recorded germinating dried spores of Aspergillus species as follows: *A. Wentii,* after more than a year; *A. niger,* about three years; *A. oryzae,* more than four years. Brefeld[2] found viability in *A. flavus* after six years; Eidam[2] in *A. fumigatus* after ten years; and Hansen[2] in *A. glaucus* after sixteen years. But in these cases the data are not given clearly enough to entirely exclude possibility of chance growth.

The organism considered in this study is a well-known species of the Aspergillaceae, *Aspergillus oryzae.* The conidial material in question was collected in 1897 from cultures of this mold—sifted out with the dust from a container in which it had been grown upon a bran base, and had been allowed to become thoroughly air dry. It was placed in a tube 10 x 100 mm, which was sealed at that time and kept in the dark under ordinary laboratory range of temperature. No attempt was made to secure a vacuum, but the tube was two thirds full of spore-dust and was sealed in the flame, hence there would be, at the most, only a very small amount of air left within.

In November, 1919, after a lapse of twenty-two years, the tube was opened for testing. Since it was considered doubtful whether the spores would show any signs of life after such prolonged desiccation, inoculations were made upon a great variety of media. Plantings were made (a) direct from the tube, (b) from dextrose-bullion suspension, after "soaking" several hours. Transferring was done, with every precaution against accidental contamination, under a glass cubicle two feet high, 36′ x 24′ at the bottom, 36′ x 12′ at the top, the sloping front plate being adjusted to any height desired above the worker's hands. The base of the cubicle is also of glass; hence the whole structure may be readily disinfected. As a further precaution, half a dozen Petri plates of nutrient agar were exposed on the floor of the cubicle while the material was being removed from the tube. All plates remained sterile but one, upon which appeared a colony of "hay" bacillus.

The following media were inoculated in duplicate, one series being incubated at 37° C., the other at laboratory temperature. In general, it may be said the higher temperature is rather more favorable or at least hastens development.

(1) Sabouraud's agar (American ingredients)	(7) Rice flour agar
(2) Czapek's agar (Formula as modified by Dox. Cane sugar the source of carbon)	(8) Wheat bran
(3) Plain gelatin	(9) White rice
(4) Sugar gelatin	(10) Brown rice
(5) Dextrose-bouillon	(11) Cracked corn
(6) Potato agar	(12) Cracked beans

Cultures of varying degrees of vigor were obtained, the organism developing upon every medium tried, much more luxuriantly, however, where there was abundant starch or sugar content, 4 per cent. or more, readily available. Considerable range in height of upright hyphae, color and size of conidial heads, etc., was found upon the various substrata; but these proved to be interchangeable according to the food, *e.g.,* when transferred from No. 3 above to No. 8, growth was comparable to that upon other cultures of No. 8 and vice versa.

On the whole, this strain can not be seen to have lost ground either in the development of typical herbage or in physiological activity. It is a vigorous diastase producer, and exhibits considerable proteolytic power as well. Since 1919 it has been maintained in pure culture upon three of the above media: Czapek agar—Dox modification; Sabouraud's formula prepared from American ingredients; and rice flour agar. It is still a thrifty strain.

The tube of spore-dust was resealed, to be kept indefinitely.

Rhizopus nigricans. In the course of the above work, although quite unintentionally, longevity was also demonstrated in another organism—the common *Rhizopus nigricans,* cultures of which were several times obtained from the tube of spore-dust where it had doubtless found entry as an invader of the original culture. Only one strain was preserved and has since been kept in culture. This, tested a year or two ago against Blakeslee's minus strain, proved to be of the plus type.

ADELIA MCCREA

PARKE, DAVIS AND COMPANY,
DETROIT, MICHIGAN

[1] Centralblatt für Bakt., 2 Abt., 1897.

[2] Cited by Lafar: "Technical Mycology," Vol. II, Part I.

THE NATIONAL ACADEMY OF SCIENCES

AT the autumn meeting, held at Cornell University, Ithaca, N. Y., the scientific program was as follows:

MONDAY, NOVEMBER 12

Morning Session

Welcome by President Farrand.

Some unexpected results of the heteroplastic transplantation of limbs: ROSS G. HARRISON.

The structure of the eye as an index of developmental deficiencies: CHARLES R. STOCKARD.

Some seasonal variation of vitamines: GEORGE W. CAVANAUGH (introduced by L. H. Bailey).

The effect of X-rays on the linkage of Mendelian characters: JAMES W. MAVOR (introduced by W. E. Castle).

Electrical resistance and thermo-electric power of the alkali metals: C. C. BIDWELL (introduced by Ernest Merritt).

Evening Session

Public Lecture, under the joint auspices of the Academy and the Alpha Chapter of the Society of Sigma Xi.

The origin and distribution of Andean bird life: FRANK M. CHAPMAN.

TUESDAY, NOVEMBER 13

Morning Session

Biographical notice of Henry Marion Howe (by title): GEORGE K. BURGESS.

Stereoisomeric styryl derivatives of some 4-quinazolone alkyl iodides and their bearing upon the problem of photosensitizing dyes: M. T. BOGERT and HELEN CLARK.

The expansion of a frequency function and some comments on curve fitting: EDWIN B. WILSON.

Note on an experimental problem of the late A. G. Webster: F. L. HITCHCOCK (communicated by Edwin B. Wilson).

On the wave-lengths of scattered X-rays: GEORGE L. CLARK and WILLIAM DUANE.

Unimolecular films of adsorbed gases: HUGH S. TAYLOR (introduced by G. A. Hulett).

Germanium: L. M. DENNIS (introduced by W. D. Bancroft).

Halogenoids: A. W. BROWNE (introduced by W. D. Bancroft).

Substantive dyes: T. R. BRIGGS (introduced by W. D. Bancroft).

Structural colors in beetles: C. W. MASON (introduced by W. D. Bancroft).

Afternoon Session

Retarded effectiveness of introduced parasites: L. O. HOWARD.

A theory as to long-time pandemic cycles of influenza: OTTO R. EICHEL (introduced by Raymond Pearl).

Metallic luster: W. D. BANCROFT.

WEDNESDAY, NOVEMBER 14

Morning Session

Presentation of Scientific Papers.

Biological studies of the Bremidae (by title): THEODORE H. FRISON (introduced by Stephen A. Forbes).

The paleobotany of the island of Trinidad. A preliminary announcement: EDWARD W. BERRY.

An aberrant F_2 ratio for the starchy-sugary endosperm factor pair in maize: R. A. EMERSON (introduced by L. H. Bailey).

The photo-luminescence of flames: EDWARD L. NICHOLS.

The effect of temperature on X-ray absorption coefficients: H. S. READ (introduced by Ernest Merritt).

Resistance temperature coefficients of thin platinum films obtained by kathodic sputtering: F. W. REYNOLDS (introduced by E. L. Nichols).

THE AMERICAN CHEMICAL SOCIETY

DIVISION OF CHEMISTRY OF MEDICINAL PRODUCTS

SYMPOSIUM: *The Chemistry of Glandular Products:* E. C. KENDALL, *Thyroxin;* T. B. ALDRICH, *Adrenalin;* H. A. SHONLE, *Insulin;* FRANK O. TAYLOR, *Pituitary extract.*

A study of the sodium salts of nucleic acid: ADRIAN THOMAS. The sodium nucleates were prepared from a nucleic acid obtained from wheatgerms. The acid was dissolved in solutions of sodium hydroxide and precipitated by pouring into alcohol, to which had been added some neutral sodium acetate to prevent emulsification. Sodium nucleates were prepared containing as a maximum eight atoms of sodium, assuming the molecule to contain four atoms of phosphorus. If potassium acetate is used in place of the sodium acetate some of the sodium is replaced by potassium. Upon using ammonium acetate instead of sodium or potassium acetate a decrease in the sodium content of the salt is found, but only a part of the sodium which is lost is replaced by ammonium. Apparently a hydrogen-sodium-ammonium salt is formed.

Butesin picrate, a new type of anesthetic-antiseptic: F. K. THAYER. Butesin picrate is the picric acid salt of butyl paraminobenzoate. There is combined in a definite chemical compound both antiseptic and anesthetic action. In an aqueous solution with a concentration of 1 part in 1,400 it produces immediate and complete anesthesia upon the eye, which lasts from ten to twenty minutes. It exerts antiseptic action and, in many cases, germicidal action against various common bacteria, in concentrations of 1:400 to 1:800. Butesin picrate is non-toxic and not irritating to the most sensitive surfaces. Incorporated into an ointment it is useful in the treatment of painful, denuded skin areas, particularly in cases of burns.

The synthesis of new cinchophen (atophan) types and incidental compounds (by title): MARSTON T. BOGERT and F. P. NABENHAUER. Cinchophens containing the quinazoline nucleus have been synthesized as follows: (1) o-aminoacetophenone to o-acetamino acetophenone, to acetyl isatinic acid, to 2-methylquinazoline-4-carboxylic acid; (2) isatine to benzyl isatinic acid, to 2-phenylquinazoline-4-carboxylic acid (A); (3) o-phthaloylamino acetophenone to phthaloyl isatinic acid, to 2-(o-carboxyphenyl) quinazoline-4-carboxylic acid (B). Of these, (A) is strictly analogous structurally to Cinchophen, except that it carries the Ph and COOH groups

on a pyrimidine instead of a pyridine nucleus. (B) resembles (A), but carries an additional COOH in o-position on the 2-Ph group. The physiological effects of these new compounds are being tested. Incidentally, many new intermediate and related products were also prepared and will be described in the published article.

The antiseptic action of the zinc chloride salt of aniline: J. W. HOWARD and F. D. STIMPERT. This salt was prepared by combining zinc chloride and aniline in molecular quantities and extracting the reaction mixture with boiling 95 per cent. alcohol. Softens at 230° C, melts at 255° C. Solubilities: at 20° C, 0.64 grms. in 100 cc H_2O; 0.87 grms. in 100 cc 0.4 HCl; 0.066 grms. in 100 cc 95 per cent. alcohol. V. slightly sol in CS_2, $CHCl_3$, C_6H_6, $(C_2H_5)_2O$. More sol. in CH_3OH and acetone. Slowly decomp. by 3N Na_2CO_3, readily by 1N NaOH or boiling H_2O. Studies on Staphylococcus aureus indicate aniline has about 5 times the disinfectant power of $ZnCl_2$. The salt $(C_6H_5NH_2)_2\ ZnCl_2$ in 0.6 per cent. soln. retards growth up to 25 mins. and will destroy in 30 minutes. Comparing with aniline and zinc chloride of the same conc. it shows a stronger antiseptic action.

Some chemical reactions of the pancreatic substance containing insulin (lantern): HORACE A. SHONLE and JOHN H. WALDO. The pancreatic substance containing insulin gives, after thorough purification, the following reactions: Biuret, xanthoproteic, Millon's, Ehrlich's diazo, reduced sulfur and Folin and Looney's reaction for tyrosine and cystine. The Molisch and glyoxylic reactions are negative. Neither phosphorus nor purines can be detected and the amino acid content is very low. This substance is soluble in dilute acids and alkalies. Its solution is laevo rotatory. The physiologically active portion dialyzes slowly through parchment paper, and can be precipitated by protein precipitants in such a state that it usually can be recovered from the precipitate. The C, H and N content of the purest preparations approximates that of protein. The data secured indicate that the active principle is either a proteose or that it is closely bound to a proteose.

Studies of the vitamin potency of cod liver oil—VII—The potency of hake liver oil (lantern): ARTHUR D. HOLMES. To secure data concerning the relative vitamin potency of cod and hake liver oils, tests were made of hake liver oil known to be true to name. Nine young albino rats were given hake liver oil in amounts varying from .00025 grams to .005 grams daily. Four animals received less than one milligram of oil daily and failed to recover from vitamin A starvation. Five animals received from one to five milligrams of hake liver oil daily and recovered, indicating that one milligram of this oil contained sufficient vitamin A to promote growth of young albino rats.

E. H. VOLWILER,
Secretary

SECTION OF THE HISTORY OF CHEMISTRY

F. B. Dains, *chairman*
Lyman C. Newell, *secretary*

Robert Brown and the Brownian movement: LYMAN C. NEWELL. Robert Brown (1773–1858), a Scotch botanist, discovered the movements of minute particles, now called Brownian movements, in 1827 while viewing a water suspension of pollen grains through a simple microscope. Impressed by this observation, he extended his investigation to suspensions of various substances—inorganic and organic, and proved that the movements are not due to anything living in the water nor to currents caused by convection or evaporation, but are fundamental and inherent in the particles. His investigation was first published in the *New Edinburgh Philosophical Journal*, Vol. 5, April–September, 1828, pp. 358–371.

Gulian C. Verplauck's account of alchemy in old New York: C. A. BROWNE. Dr. Browne says very correctly "that within the past few years a sufficient amount of documentary and literary material has been gathered together in different quarters to prepare a volume of considerable size upon the history of alchemy in America," and in the present communication he narrates in a delightful way what he discovered upon ruminating in a publication entitled the "Talisman" for the year 1829. It is the story of Max Lichenstein, who actually conducted a "transmuting laboratory" down in Wall Street, New York. No one would have dreamed such a thing possible, but it was, until he saw fit to migrate, and, adds Verplauck, "I have heard that his furnace has again been seen smoking behind a comfortable stone house in the comfortable borough of Easton, Pennsylvania, a residence which he chose, not merely on account of its cheapness of living, nor its picturesque situation, but chiefly for its neighborhood to Bethlehem, where dwelt a Moravian friend of his, attached to the same mysterious studies."

Ten minutes with the ancients: EDGAR F. SMITH. In this communication attention was called to several famous paintings of eminent alchemists. Pictures of men who traveled through Europe in the interests of alchemy were exhibited, and also the title page of a very famous volume, devoted to alchemy, by Carbonarius, was shown. It was explained how very helpful this publication would be to students of the present who had the inclination and desired to acquaint themselves with the writings of the so-called genuine practitioners of the art of transmutation.

Jacob Green—chemist: EDGAR F. SMITH. This paper records the life-work of a forgotten American chemist who taught his science in Princeton University for four years (1818–1822), and in 1825 became one of the founders of Jefferson Medical College where he was the first professor of chemistry (1825–1841). Green was a splendid example of the old-fashioned, broadly trained teacher. He made worth while contributions in botany, paleontology, natural history, physics and chemistry. His "Chemical Philosophy," in 1829, presented the fundamentals of chemistry in a remarkably lucid fashion. In fact, all of Green's books exhibit his complete grasp of his subject. His interviews with Dalton, Faraday, Gay-Lussac and other sciencific worthies are most illuminating. Green was a superb teacher of chemistry.

Some notes on a "reader of chemical history": EDWARD KREMERS.

LYMAN C. NEWELL,
Secretary